

Remarks

Claims 1 and 2 have been amended and new claims 21-36 have been added. It is submitted that claims 1-36 remaining in the application are patentably distinct and allowable.

Attached hereto is a marked-up version of the changes made to the specification and claims by the current amendment. The attached page is captioned "Version with markings to Show Changes Made."

A check in the amount of \$372 is enclosed for added claims fee of \$288 for 16 claims in excess of 20 and a fee of \$84 for one independent claims in excess of three.

Applicant does not believe that any fees are due in connection with this submission. However, if such petition is due or any other fees are necessary, the Commissioner may consider this to be a request for such and charge any necessary fees to deposit account 23-3000.

The Examiner is invited to call the undersigned should any questions arise.

Respectfully submitted,

WOOD, HERRON & EVANS, L.L.P.

By:

Joseph R. Jordan, Reg. No. 25,686

2700 Carew Tower
441 Vine Street
Cincinnati, Ohio 45202
PH: (513) 241-2324
FX: (513) 421-7269

VERSION WITH MARKINGS TO SHOW CHANGES MADE

In the Specification

Paragraph number [0004], [0006], [0007], [0012], [0014] and [0064], have been amended as follows:

[0004] This invention relates to inductively-coupled plasma (ICP) sources used in the processing of semiconductors. The invention is particularly applicable to high-density inductively-coupled plasma (HDICP) sources in which RF energy is inductively coupled through a dielectric material that is protected by a slotted deposition baffle to energize a plasma for depositing an electrically conductive material onto, or etching an electrically conductive material from, a semiconductor wafer[, an electrically conductive material].

[0006] Inductively coupled sources are becoming widely used for processing systems used in semiconductor manufacturing. Typical ICP sources employ an antenna that couples RF energy into a working, or processing, gas in a vacuum chamber, thus exciting a plasma in the gas. Such sources further employ an electrically insulating window or other electrically insulating material barrier between the antenna and the processing zone. A window, where used, may provide a barrier between atmospheric air and the vacuum of the chamber. Early use of high frequency coils for ionization of evaporated particles of coating material is described in U.S. Patents Nos. 3,974,059 and 5,178,739.

[0007] In ICP semiconductor processing systems, the ICP source is an integral part of the vacuum chamber that contains the working or processing gas that is used for processing of the semiconductor wafers. For metal deposition and etching applications, a dielectric window or other electrically insulating structure has to be protected from plasma to avoid building-up conductive coatings on the surface of the insulating material that could prevent efficient RF power delivery into the plasma. Surface protection of the insulating material is provided by a structural device, namely, a deposition baffle placed between the plasma and the insulating material. The electrically insulating material is referred to hereafter as a window. Such a window is typically formed of a dielectric material such as ceramic. Deposition baffles made of slotted shields are described in U.S. Patent Nos. 4,431,901; 4,795,879; 4,897,579; 5,231,334; 5,234,529; 5,449,433 and 5,534,231. Their use in ionized physical vapor deposition (iPVD) systems is described in U.S. Patents Nos. 5,800,688 and 5,948,215, using cylindrical sources, and in U.S. Patent Nos. 6,080,287 and 6,287,435 using planar flat and three-dimensional antennae.

[0012] An important property of a deposition baffle is its transparency to electromagnetic fields. Slots allow azimuthal magnetic flux, which [are] is produced by currents flowing in the conductors of an antenna that encircle the conductors in planes normal to the conductors, to pass through the baffle. An electric field is induced across the gaps between adjacent [slats] slots of the baffle that border the slots, which is in a direction such that it supports $E \times B$ movement of flux from the gap and away from the antenna. The transmission coefficient may reach values up to the 0.8 – 0.9 range. An electrically conductive deposition baffle, however, can produce two adverse effects on

antenna-to-plasma coupling properties: (1) magnetic shielding of the antenna current I_a , and (2) possible significant ohmic losses. Both effects are stronger when magnetic flux normal to the surface of the baffle is increased.

[0014] The initial ionization of gas in the chamber requires a high enough voltage to cause electron and ion generation from neutral atoms. Further, to maintain the plasma, at least as many atoms have to be ionized to produce ions and electrons as are lost by collisions within the chamber [volume] space or [on] with the chamber walls. If too many electrons are lost, the plasma collapses or is never formed. A well-designed deposition baffle shields most of the electric field from the antenna and makes it difficult to ignite a plasma by an electric field from the antenna. Increasing the RF current through the antenna to produce stronger electric fields in its vicinity can result in high voltage at the antenna that can produce an atmospheric discharge outside of the chamber, and thus unsafe operation and potential component damage. Further, the lower the pressure in the chamber, the more difficult is plasma ignition.

[0064] Inside of the window 23 is a deposition baffle 30 of electrically conductive material having, in the embodiment shown, a plurality of parallel linear slots 31 therethrough. Preferably, the baffle 30 is metal. The [metal] baffle 30, between each pair of adjacent slots 31, is in the form of an elongated slat 32. The coil 21 has a plurality of parallel conductor segments 24 that lie close to the outside of the window 23 and interconnected by return segments 25 configured so that the currents I_a in the segments 24 flow in the same direction and generate the magnetic field B_a (Fig. 1A) that excites a high density plasma 40 within the chamber 11. The slots 31 in the baffle 30 lie in planes that are perpendicular to the segments 24 of the coil 21. The flux lines of the magnetic field B_a lie in these planes. These flux lines loop through the slots 31 and around a volume of gas in the chamber 11 adjacent the baffle 30, thereby coupling the RF energy from the coil into the gas within the chamber 11 to sustain the plasma 40 that has been ignited in the gas. This plasma is manifested as a plasma current 41 of charged particles of processing gas that opposes the field from the coil.

In the Claims

Claims 1 and 2 have been amended as follows:

1. (AMENDED) A deposition baffle for protecting a dielectric window in a plasma processing chamber while facilitating inductive coupling of RF energy from a coil outside of the window, through the window and baffle, and into a plasma within the chamber, comprising:

an electrically conductive body having a window side and a plasma side; the body having a plurality of slots extending therethrough between the sides thereof;

the slots having walls defined by surfaces of the body and [are] configured to block line-of-sight paths through the body for particles in the chamber moving from the plasma side of the body to the window side of the body;

a plurality of the slots each having a structural element therein fixed to the body on substantially only one of said sides of the body; and

the elements having connections to the body distributed on the baffle so as to improve the uniformity of the distribution of power coupled into the plasma through the baffle without substantially limiting the effectiveness of inductive coupling through the baffle.

2. (AMENDED) The baffle of claim 1 wherein:

the slots have chevron-shaped cross sections when viewed in a direction parallel to the length of the slots.

New Claims 21-36 have been added.